Report on the Operational Trial Microfibre and Copper Trial in a Healthcare Setting
January to March 2008
## Glossary

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>HFS</td>
<td>Health Facilities Scotland</td>
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<tr>
<td>HAI</td>
<td>Healthcare Associated Infections</td>
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<td>SGHD</td>
<td>Scottish Government Health Directorate</td>
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<td>UMF</td>
<td>Ultra Micro Fibre</td>
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<td>UCLH</td>
<td>University College London Hospitals</td>
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<tr>
<td>CUWB 50</td>
<td>Copper Based Biocide (CuWB50)</td>
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<td>ICICs</td>
<td>Manufacturer of CUWB50</td>
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<td>TVC</td>
<td>Total Viable Counts</td>
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<td>MRSA</td>
<td>Methicillin-Resistant Staphylococcus Aureus Biomedical</td>
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<td>BSO</td>
<td>Biomedical Scientific Officer</td>
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<td>IBC</td>
<td>International Bulk Containers</td>
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<tr>
<td>MSDA</td>
<td>Material Safety Data Sheet</td>
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<td>FMS</td>
<td>FM Specific Consultants Ltd</td>
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Overview

HFS commissioned a trial funded by Scottish Government Health Directorates (SGHD) on the use of microfibre cleaning products and copper compound CUWB50 in NHS Dumfries and Galloway and NHS Grampian to obtain operational and microbiological analysis from its combined use within patient areas. This paper provides the trial background, results and recommendations.

As the NHS Grampian protocol did not follow the protocols agreed by the Project Board, the microbiological results relating to the trials in NHS Grampian are not included in this report.

MRSA and C difficile were very rarely isolated in NHS Dumfries and Galloway study locations, making reliable statistical analysis specific to these two organisms impossible, therefore this report focuses on the study and the relative effects on total viable counts (TVCs).

Background

The increased cases of Healthcare Associated Infections (HAIs) in Scotland has led to an increase in healthcare costs and public anxiety. The rise in antibiotic resistant bacterial infections has been particularly difficult to control and has prompted a review of hospital hygiene and infection control.

Health Facilities Scotland (HFS) is conducting a number of trial projects to assess and manage the risk of infection within Facilities Management within Scottish Healthcare Premises. In recognition of the contribution of cleaning, HFS has produced a National Cleaning Specification and a National Education and Training Framework for Domestic Assistants and Housekeeping Staff.

In 2007, the SGHD allocated funding to HFS to identify and investigate cleaning innovations which may improve overall standards and have an effect on the reduction of HAI. The HFS Domestic Services Advisory Group (consisting of representatives of all operational NHS Boards) was consulted and it was agreed that the funding would be used to investigate the effectiveness of ultra micro fibre (UMF) in the healthcare environment.

As University College London Hospitals (UCLH) had already undertaken a comprehensive trial project evaluating the efficacy of ultra micro-fibres (UMF), HFS decided as part of their investigations and observations to meet with the UCLH Project Team lead, Dr Vanya Gant, to understand the demonstrated value of this technology.

HFS were informed of the many benefits of using UMF in hospitals through the various studies which ULCH had undertaken, HFS were also informed of one of the problems with UMF in that it left live bacteria on cloths after cleaning. This would cause logistical problems of moving contaminated products around the healthcare setting. Therefore a biocide was required to kill the microorganisms collected on the UMF.
Commonly available disinfectants such as chlorine (bleach) were unsuitable as they affect the integrity of UMF and the environment. UCLH had been asked to investigate a novel copper based biocide CUWB50. The biocide was tested for effectiveness and safety at UCLH and found to be effective and safe; however, the use of combined UMF and CUWB50 had not been considered or evaluated in the operational environment. The HFS team took a view these were complimentary and had potential for use in a healthcare setting when combined.

UCLH had tested the use of the combination of copper biocide and UMF in cleaning trials in the confines of the lab and the results displayed that this combination produced a significantly cleaner result than standard mop and bucket used for hospital cleaning. These results were lab based and there was a need for trials in a ward environment.

HFS considered the possible benefits to the Scottish healthcare system from the use of microfibre studies. HFS discussed the project with 16 Health Boards to identify volunteers. From this it was decided that NHS Grampian and NHS Dumfries and Galloway would be selected.

Discussions took place with the manufacturers of UMF and the CUWB50 to conclude commercial arrangements for the trial sites.

The Project Team

A Project Team was established; this was chaired by David Bryson of NHS Dumfries and Galloway and contained operational management and microbiologists’ representatives from NHS Dumfries and Galloway and NHS Grampian and representatives from HFS. A Project Manager was added to the team, prior to the practical requirements of the project commencing. UCLH were invited to provide professional consultancy due to their previous experience with the products. The Project Team consisted of the following members:

<table>
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<tr>
<th>Project Team Member</th>
<th>Organisation</th>
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<tr>
<td>David Bryson (Chair)</td>
<td>NHS Dumfries and Galloway</td>
<td>General Manager Operations</td>
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<td>Angela Brown</td>
<td>NHS Dumfries and Galloway</td>
<td>Domestic Manager</td>
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<td>Dr David Hamilton</td>
<td>NHS Dumfries and Galloway</td>
<td>Microbiologist</td>
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<td>Audrey Bell</td>
<td>NHS Grampian</td>
<td>Domestic Manager</td>
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<td>Dr Tom Reid</td>
<td>NHS Grampian</td>
<td>Microbiologist</td>
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<td>David Bedwell</td>
<td>HFS</td>
<td>Assistant Director</td>
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<td>Paul Kingsmore</td>
<td>HFS</td>
<td>Director</td>
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<tr>
<td>Alistair Leonard</td>
<td>Monklands Hospital</td>
<td>Chair of the Scottish Infection Research Network</td>
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<tr>
<td>Lynn Ballantyne</td>
<td>FM Specific Consultants</td>
<td>Project Manager</td>
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The Project Team commenced liaison in preparation for the practical trials in the autumn of 2007. Draft Protocols were prepared in October 2007 and the first Project Team meeting took place in November 2007.
The Project Protocol

The draft protocol study design (version 3) was prepared in October 2007 by Dr Reid of NHS Grampian. The protocol identified the study design for the trial of the copper compound and UMF in NHS Grampian. In relation to the length of the trial, this protocol identified there would be a four to six week period of swabbing on the current cleaning methods and a further four to six week period of swabbing using the CUWB50 and UMF.

This draft protocol was approved by the Project Board.

The minutes of the project group meeting of November 2007 identified that the study design should be a four-week lead in, followed by a six-week trial, followed by a two-week washout.

Dr Reid's team in NHS Grampian later produced version 4 in December 2007 which identified the study design at Woodend Hospital would be reduced to a three week trial with one of these weeks in each ward using UMF and CUWB50.

Dr Hamilton of NHS Dumfries and Galloway produced the draft protocol for the trial in Dumfries and Galloway Royal Infirmary. This identified a six-week trial period, where copper CUWB50 and UMF was used for three of the weeks and UMF and water was used for three of the weeks followed by a two-week wash out.

HFS sought advice on the protocol change received for NHS Grampian (to generate the data over three weeks not the agreed six weeks) and after discussion decided to continue with the trial at NHS Grampian even though the protocol study had changed, as the NHS Grampian trial may still produce strong operational data. The laboratory results from NHS Grampian would not be included in the final report as the results were not gathered in line with the protocols agreed by all parties prior to the study start. However, operational experience of the trial are included in the report.

It should also be noted that the protocol at NHS Dumfries and Galloway was subsequently increased after the first three weeks (day 22) to add an additional wash out week at week four, the protocol then continued as planned.

Ultra Microfibre Products

Microfibre is radically different to the classical wet loop cloth products. The product is produced by splitting larger polyester/polyamide fibres to have a density of 1 denier. Ultra microfibre UMF is thinner still with a density of < 0-3 denier.

UMF strands attract dust as shown in Figure 1, the dirt and dust is then captured within the fibres as shown in Figure 2. The product has a dual cleaning property, in a dry state the static charge attracts dust and debris and in damp state the capillary action draws soil and bacteria into its fibre network. Both dry and wet UMF products demonstrate high efficiency removal of particles and
biofilm. The UMF performs well on flawed surfaces through its removal of bacteria lodged in small surface abrasions.

![Figure 1: Cleaning action of UMF versus cotton products](image)

Figure 1: This shows the cleaning action of UMF versus cotton products

![UMF Strands](image) ![Static attraction of dust](image) ![Dirt captured within fibre](image)

Figure 2: Scanning Electron Micrographs demonstrating the action of microfibre

The industry widely recognise that the use of UMF with water within healthcare establishments versus traditional woven cloths will display a greater removal of bacteria from surfaces, and that previous trials have shown that UMF has outperformed conventional cloths in comparative tests including removal of dried-on protein rich contaminated surfaces, favourable to bacteria. Microfibres do not require detergents or biocides, micro-organisms are effectively entrapped within the microfibre weave but remain viable and create a potential contamination hazard. Microfibre cloths are reusable therefore a robust laundry management process is essential to mitigate contamination risk. Commonly available disinfectants such as chlorine (bleach) were unsuitable as they affect the integrity of UMF and have a negative effect on the environment.

Laboratory trials carried out on copper based biocide CUWB50 had tested the product for effectiveness and safety and found it to be effective and safe for use in a Healthcare environment.

Previous laboratory work also identified that by impregnating the cleaning products (UMF) with the CUWB50 this product killed the pathogenic bacteria providing a combined better product for cleaning in the healthcare environments.

This report does not consider or have a view on which commercial UMF product is best. The chosen UMF was selected on the basis of appropriate commercial terms.
History of Copper

Copper has been used for many years in various environments including health and food environments. Egyptians used copper pots to store water; the Romans put copper coins in barrels to keep water clean and fresh on voyages. The human RDA for copper is 1-5 mg/day. Skin sensitisation to copper is very rare. Aquatic biosystems (algae, fish etc) are particularly sensitive to copper therefore the correct disposal of copper is essential.

The copper compound CUWB50 used in this trial is a highly charged copper ionic electrolyte compound and is the proprietary to and patent protected (e.g. US 7,060,302) by Remedy Research Ltd.

The copper compounds produced by this organisation have been shown to have potent anti-bacterial and anti-fungal activity and are much safer than current biocides for example halogens, peroxides and phenols; they have potential applications in environmental cleaning and in healthcare products.

The copper compounds have been extensively tested for antibacterial activity in the Clinical Microbiology Dept at UCLH (under contract to Remedy Research). They are currently studying the mechanism(s) of action of these compounds.

Results from the laboratory testing carried out by the UCLH showed that the copper compounds kill all of the pathogenic bacteria that cause problems in hospitals and in the environment including antibiotic-resistant clinical isolates of: MRSA, ACCB, VRE, C. difficile, E. coli, E. faecalis, Pseudomonas, Klebsiella.

Safety

CUWB50 is a safe and effective biocide formulated from components which are all on the FDA GRAS (generally regarded as safe) and Food Codex CUWB50 is safe at 300 ppm (as used in pre-medicated UMF cloths and mops) and has the same pH as ascetic acid (vinegar). CUWB50 has undergone an extensive Cytotoxicology study and is safe to handle up to 1,000 ppm. The use for the healthcare trials is at 300 ppm. CUWB50 has no fumes or scent. It was successfully used in the HFS field trials without irritation or negative side effect. Although the Cytotoxicology study and MSDS are not included with this report they are available.

How the trial was undertaken

HFS communicated with project representatives from Dumfries and Galloway and Grampian and agreed trial locations within both Boards.

The trial locations were:

<table>
<thead>
<tr>
<th>Ward</th>
<th>Location</th>
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<tr>
<td>16</td>
<td>Woodend Hospital Aberdeen</td>
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<tr>
<td>18</td>
<td>Woodend Hospital Aberdeen</td>
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<tr>
<td>36</td>
<td>North Foresterhill - ARI Aberdeen</td>
</tr>
<tr>
<td>36</td>
<td>North Foresterhill - ARI Aberdeen</td>
</tr>
</tbody>
</table>
Ward 7     Dumfries and Galloway Royal Infirmary, Dumfries
Ward 18    Dumfries and Galloway Royal Infirmary, Dumfries
Ward 10    Dumfries and Galloway Royal Infirmary, Dumfries
A & E      Dumfries and Galloway Royal Infirmary, Dumfries

The Trial protocols were drawn up by the Boards’ microbiologists and agreed by the Project Board. Identified below are the study designs taken from the protocols drawn up by the Microbiologists at each Health Board.

**NHS Grampian Study Design**

The study was designed with two separate arms:

**Woodend Hospital**

The use of microfibre mops and cloths has been part of the established practice in Woodend Hospital for two years prior to the trial. The study was designed to compare the microbial load and the bacterial contamination (TVC/MRSA/Cdifficile) in two selected wards at Woodend Hospital (Ward 16 and Ward 18, Department of Medicine for the Elderly).

At Woodend Hospital, the study commenced at the agreed date with a random allocation between wards 16 and 18 of UMF products with water or alternatively copper solution. The procedure continued for a period of 5 days in each ward on the designated cleaning routine (Monday through Friday) and ceased on Friday evening. Over the weekend and the subsequent week (Monday to Friday) normal routine cleaning took place (microfibre mop and cloth only). In week 3 of the study, the random allocation allowing alternate treatments, i.e., UMF mop and cloth with copper solution to one ward and UMF mop and cloth to the other ward took place over the designated 5 day period (Monday to Friday). The study was completed by the end of week 3 when the samples from all wards had been collected.

The wards were swabbed in 10 designated areas 3 times a day for 5 consecutive days (Monday through Friday) by a Biomedical Scientific Officer (BSO) specifically employed for this job. The contact plates, once collected from the designated rooms or appropriate hospital areas, were transferred directly to the Microbiology Laboratory under the direction of Dr Tom Reid and were cultured appropriately. The Woodend Hospital study took 3 weeks to complete. Culture plates on each day from each of the 10 designated areas of the 2 wards were collected pre cleaning and 1 and 4 hours post cleaning in each area.

The second part of the study at the Woodend Hospital involved the same wards and the same rooms or ward areas with the same BSO taking the same contact plates from the same areas in each designated potentially infected room or hospital areas.

On this occasion, however, the microfibre mops and cloths were applied as a cleaning routine in the alternative ward and plate collection was conducted on exactly the same basis as in week 1.
The study was designed to establish a baseline for the type and levels of bacteria load over 5 consecutive days in one week in the selected test areas using the current cleaning procedures (UMF microfibre mops and cloths) without changes to the procedures and then compare these, each for a period of 1 week, against the same microfibre mops and cloths using in addition a copper solution specified by UCLH and ICICS PLC. However, given the reduced timescale these could not be statistically analysed.

**Aberdeen Royal Infirmary - Foresterhill**

The second arm involved a designated ward at ARI (ward 36 north and south wings, vascular surgery unit). Here the standard cleaning procedure involved hot soapy water and a detergent solution and UMF mops and cloths. However, in order to accommodate a training period for staff not accustomed to using the UMF systems, a week’s training was included. Having completed a period of supervised training, these Domestic Staff then undertook a 3 week study (exactly as Woodend hospital) whereby a period of active treatment lasting 5 designated days randomly allocated to either standard hot soapy water and detergent solution or microfibre mops and cloths. This lasted for a period of 5 days followed by an interval week where standard cleaning procedures (hot soapy water and detergent solution) were applied in the usual way and followed on the final week with alternate allocation of microfibre and mop and cloth verses hot soapy water and detergent solution, again over a 5 day period. It is important to note that the same cleaning personnel trained in the same UMF mop and cloth cleaning techniques were used throughout the study under supervision and the same ward contact points were used as well as the same BSO dedicated to this aspect of the work.

In each arm of the test protocol, the trial was to establish a baseline for the microbial load in the selected test areas using the standard cleaning procedures without changes to the procedures, products or staff other than specifying the time at which the rooms should be cleaned.

The test areas swabbed at 10 points, to a pre determined plan, pre cleaning plus 1 hour and plus 4 hours post cleaning on each of the 5 days in the designated weeks by arrangement with the individual wards. The swabs were assessed for total viable counts (TVC) and the presence of MRSA and C difficile organisms.

The study was supervised in each of the selected rooms or hospital areas by a qualified, experienced dedicated Microbiologist. The investigating Microbiologist or his designated assistant was the same throughout the study.

Evaluation of the study was by comparison of TVC and the presence of MRSA/C difficile in all individual rooms and hospital areas involved in the study.

**NHS Dumfries and Galloway - Study Design**

**Cleaning Methodology**

The use of microfibre mops had been part of the established practice in NHS Dumfries and Galloway for several years. The study was designed to compare
the total microbial load and that of MRSA and C.difficile in particular in three wards and one unit in Dumfries and Galloway Royal Infirmary, the principal Acute unit in NHS Dumfries and Galloway. Microfibre cleaning of non-floor surfaces is not normal practice but was introduced for the trial.

The study began with two wards being randomised to start with microfibre alone and the remaining two with microfibre and copper. After three weeks of continuous use, the two methods were reversed for a further four weeks, a two-week washout period for the units where copper was used in the second three-week timeframe. Those who undertook the microbiological sampling and examination were blinded to which method were in use where. All other cleaning methods and materials were unaffected and the same across all four units.

Microfibre mop and cloth cleaning techniques were used throughout the study under supervision and the same wards and contact points were used as well as the same BSO dedicated to this aspect of the work.

Cleaning of the test rooms was undertaken at the same time of day whenever possible. When clinical issues prevented this, the domestic informed the domestic supervisor who ensured the laboratory was informed. Monday, Wednesday and Friday were the test days.

In each of the two arms of the test protocol, the trial established a baseline for the microbial load in the selected test areas using the standard cleaning procedures without changes to the procedures, products or staff other than specifying the time at which the rooms would be cleaned.

Laboratory methods

The laboratory staff undertaking the testing, resulting and data analysis did not know which ward was under test and which was a control location.

The test area was swabbed at 10 points according to a pre-determined plan, pre-cleaning 1 and 4 hours, post-cleaning on each of 5 days in the designated weeks by arrangement with the individual wards. The order of sampling each site was: nutrient agar, MRSA, C. difficile plate. The swabs were assessed for total viable counts (TVC) and the presence of MRSA and C.difficile organisms.

The study was supervised in each of the selected rooms or hospital areas by a qualified, experienced, dedicated Microbiologist or his designated assistant. Responsibilities for selected swabbing points were defined on a pre-determined sheet and covered both hard and soft surfaces which are susceptible or common to hand touch.

The investigating Microbiologist or his designated assistant, were the same throughout the study.

TVC data were analysed using statistical methods specifically selected for the design of the trial and the data distributions were obtained. Multivariate statistical analyses were used to establish the level of significance of any perceived differences, and to eliminate the effects of other confounding factors.
Collection of samples were as described in main protocol document. All samples were incubated at 30 deg C for 48 hours in air. Enumeration of the number of colonies for total viable count was undertaken using the nutrient agar plate. The MRSA plates (Brilliance MRSA Contact Plates, Oxoid UK) and C. difficile plates (Braziers with Lysozyme, Oxoid, UK) were examined for colonies suggestive of MRSA and C. difficile respectively. Full identification was undertaken using standard methods as described in the national Standard Operating Procedures.

**Mop and Cloth Impregnation**

All UMF manufacturers and experienced users of UMF will stress that laundry and laundry logistics of these products is the main reason for failure and breakdown of consistent product delivery. The use of copper presented additional challenges because of the task of adding the correct dilution of CUWB50 and the removal and disposal of the copper.

The project group decided to launder and impregnate the UMF products off site using one trained laundry team; this reduced the incidence of human error. This process allowed the local domestic teams to focus on the UMF products use rather than spend time on the technical considerations of adding the copper compound and ensuring the laundry of products met the product specifics required.

Various laundries were considered and the laundry which currently supplied Dumfries and Galloway Royal Infirmary with UMF was selected. There were potential logistic issues as the laundry was based in Skegness, Lincolnshire in England, however the laundry set up and experience led to their selection for the trial.

Mops and cloths requirements were calculated by the managers and the system UMF sets were then ordered to allow for UMF sets to be located at various steps of the laundry journey, dirty, transport, clean, transport, shelf and in use. Having a laundry closer to the point of use would have reduced the product requirement but would have increased the local responsibility.

The laundry developed their local operational and safety systems to launder and pre dose the UMF with the copper CUWB50. The impregnated mops and cloths were then batched in the central preparation area in Skegness, to the bag quantities required by the local manager and transported and delivered to the agreed drop off point. The same system was used for the UMF, which was not to be diluted with the copper CUWB50, after drying these products were batched, bagged and delivered with the other products to the agreed location.

In the laundry the UMF cloths and mops were rinsed and the copper bearing rinse solution was held in 1,000L IBC, this allowed copper to concentrate for recycling. Where copper could not be used and required to be disposed off, a specialist environmental mitigation firm collected the copper bearing rinse solution and properly dispose of the solution.
Operational Use

The use of microfibre in cleaning is a cultural change from the historic traditional cleaning methods, there are real technical differences in its use to ensure successful outcomes, therefore there is a need for robust training systems, good supervision and management.

The employees at NHS Grampian and NHS Dumfries and Galloway were all at various stages of knowledge and skills in the use of UMF products. The Aberdeen Royal Infirmary had never used any UMF products, Woodend and NHS Dumfries and Galloway had experience of the UMF products. Products were ordered and local training took place in advance of the trial start date.

Woodend Hospital and NHS Dumfries and Galloway Royal Infirmary trials commenced the third week in January, ARI used this week for additional on the job training after the new product had arrived and commenced the ARI trial the fourth week in January.

The importance of correct UMF cloth use was highlighted to the staff during their training prior to the trial commencing. Domestic staff have traditionally damp dusted by gathering together a bundle of disposable fabric or cloth and cleaned by moving the damp bundled fabric in a figure of eight across the surface to be cleaned. The UMF cloth requires to be used differently to maximise the use of the product. After laundering the UMF cloth must be folded into quarters, the dosed product must then be used flat with the whole hand behind. After side one has been used the cloth is turned over and a new side used, this process continues until the 8 sides of the cloth have been used.

As outlined in the protocol the trial plan contained areas where the UMF was to be used with water and areas where the UMF was to be used with the copper biocide CUWB50. Products containing CUWB50 biocide would be taken from the delivery bag and used with the manufacturer instructions with no fluid added locally. Areas where the protocol identified the use of UMF and water, the product was diluted locally, using manufacturers wetting kit, with tap water only. The results were compared as per the protocols.

The CUWB50 biocide has a 7 day life after impregnation, which helps with holding stock and usage at the hospital sites.

Cleaned hospital surfaces were sampled during the trial to measure cleaning efficacy. Cleaning continued with normal frequencies of clean and standard methods of cleaning and the only change was the supply of mops and cloths used.

The used mops and cloths were then sent to the external laundering service for cleaning and the impregnation of copper, these were then delivered again ‘ready to use’, sealed in packages.

Operational Feedback

Operational Cleaning Hours
A review of the specific operational requirements of the hospital domestic services was carried out at each hospital by the project manager. This was carried out to gather any information which may have been needed to identify variances as the trial progressed.

This analysis looked at the available domestic time per ward, the tasks the domestics carry out including non cleaning duties such as patient catering tasks and identifying the time spent cleaning per m² per ward/department.

This was an extremely interesting task as both NHS Grampian and NHS Dumfries and Galloway, now operate to the standard monitoring framework, therefore the cleaning outputs should be the same.

FMS used their benchmark on cleaning hours and task time for patient related duties, one hospital was identified as having an excessive number of hours on the floor, the other hospital had insufficient hours on the floor.

The hospital with the lower hours had been contracted to a private contractor previously where the hospital with the excessive hours had always been provided by an in-house team.

**Meetings with trial Domestic employees**

The Project Manager met with a sample number of Domestic Assistants who were involved in the trial at each of the trial locations.

The purpose of these meetings was to allow the staff to record their thoughts on the physical use of the trial products and to record their views of the resulting standards within their work environment. Staff were requested to complete trial score sheets. These scoring sheets requested feedback from the Domestic Staff on their opinion on; the ease of use of equipment and UMF, the performance of the products, the CUWB50 and water, their preference, the task timings, any safety issues and any user comments.

Where available, nursing staff were also requested to make comment on the trial and any effects on the cleanliness standards within their ward.

The comments from the interviews have been presented in Appendix 1.

**NHS Dumfries and Galloway**

The staff at Dumfries Royal Infirmary were consulted on the 1st April 2008, all trials had been completed by this date.

The Dumfries standard system of cleaning prior to the trial was a UMF mop, which had been predosed at an offsite laundry and a disposable cloth for cleaning non-floor surfaces.

The staff in the NHS Dumfries and Galloway trial used UMF products which arrived pre dosed with CUWB50 during the copper and UMF trials and arrived dry during the UMF and water trial weeks.
The domestic employees scored the UMF mops and cloths with copper CUWB50 higher than the scores issued to the UMF products and water.

Domestic staff explained they found dosing the UMF locally with water, during the UMF and water weeks, time consuming to set the trolley up and wait for the mops to become wet, as their local procedure is to receive the UMF mops pre dosed from the laundry and the pre dosing with water locally, took time away from their available cleaning time.

There were comments past at the time of interview that on occasions during the UMF and copper CUWB50 trial the UMF could dry out, the employees did not report this into the ward trial manual or to the supervisory or management team therefore this could not be investigated and any problems rectified. Employees advised they rectified themselves by using a new UMF dosed product.

The Domestic Staff were aware of the UMF design features in the mop handle and the trolley as they currently used the UMF product. They did introduce a dry UMF product and good operational comments were received on the use of these.

The UMF cloths were a new introduction to the NHS Dumfries and Galloway domestic team, staff were trained on the specifics of the cloth use and the use of the eight sides, staff were also given the opportunity to use the products prior to the trial commencing. Most comments related to the use of the UMF cloths were positive, there were however a few comments on the cloths not retaining the flat structure and the use of eight side at times becoming an operational challenge. Domestic staff did report that the disposable white gloves did turn yellow during the UMF cloth use with copper CUWB50. The copper will deposit on any protein item and this residue is likely to be the copper on the glove protein deposited during cleaning, this would not be harmful to the Domestic Staff or the patients. There was no surface staining observed.

There were no slippy or stained floors reported. One Doctor passed comments that there was a metallic smell in the air.

**NHS Grampian**

The staff at NHS Grampian were consulted on 18th March 2008, all trials had been completed by this date.

**Woodend Hospital**

The Woodend Hospital standard system of cleaning prior to the trial was a UMF mop and a UMF cloth used with water which were laundered within a local NHS Grampian laundry.

The Domestic Staff in the trial used UMF products which arrived pre dosed with CUWB50 during the copper and UMF trials and arrived dry during the UMF and water trial weeks.
The domestic employees scored the UMF mops and cloths with copper CUWB50 similar to the scores issued to the UMF products and water, both systems scored mostly full marks from the employees.

Domestic staff explained they thought the time to set up and use both the UMF with water and UMF with copper to be very similar.

The Domestic Staff were aware of the UMF design features in the mop handle and the trolley as they currently used the UMF product. The staff did explain that they felt the design of the products used during the trial were slightly better than they currently use. They explained that it was easier to get into corners. The staff reported that they could see more dirt on the mop when the copper was used. Two staff also commented it was easier to use the UMF and Copper as it gave less resistance, seemed to glide, than when they used the UMF and water.

There was no safety issues raised and no negative comments made relating to the use of CUWB50 within the wards. Nurses commented that they were happy with the trial.

**Aberdeen Royal Infirmary Hospital**

The Aberdeen Royal Infirmary standard system of cleaning prior to the trial was a traditional flat mop (not UMF) and hot water with detergent, the non-floor surfaces were cleaned with a disposable cloth.

The Domestic Staff during the trial used their traditional cleaning methods and UMF with water. There was no copper used at Aberdeen Royal Infirmary.

The Domestic Staff at Aberdeen Royal Infirmary rated the microfibre mopping system highly and the microfibre cloths very low, although three out of four staff said that they would prefer to use the microfibre system to the current systems, which the ward uses.

There were excellent comments made about the trolley design, mop pole design, the Domestic Staff particularly liked the adjustable handle height, they felt there was less strain placed on their back and neck, the fact that there was no need to continually return to the domestic services cupboard to dispose of dirty water and obtain fresh cleaning water increased available cleaning time and reduce the safety risk of water spillages. Floor surfaces were also left drier after the UMF and water.

Most comments around the microfibre cloths related to them being difficult to use, particularly around the employees using eight sides of the cloth to clean and the general view was they preferred to bundle the fabric together rather than use the flat sides. Domestic employees did report that there was an improved visual difference when using the UMF although stubborn marks were difficult to remove.

There were no safety issues raised during the trial of UMF and water.
Operational Summary

The comments recorded reflect the employee views at the time of the Project Manager’s visit.

This trial took the staff through a period of change and it is important to understand where each group started in relation to the change each group moved through.

For example, the NHS Dumfries and Galloway staff did not score the microfibre water system high; they currently do not carry out the water dosing task on site as the products are delivered from the laundry pre dosed. Another example was Aberdeen Royal Infirmary who scored the use of microfibre cloths very low; they currently use disposable cloths and have had limited exposure to microfibre products.

A further example was Woodend Hospital who currently use UMF mop and cloth products and have had low levels of change during the trial and scored all UMF systems high.

Therefore, there is a possibility that the individual scores may relate in some way to the personal change each person has worked through during the trial. This also highlights the need to take change management into any potential widespread introduction.

The Project Manager also wanted to capture any safety issues and identify any known nursing difficulties. There were no safety issues or nursing issues recorded at any of the NHS Grampian locations.

There were however two safety issues raised at NHS Dumfries and Galloway; one related to a member of staff who had a rash on an index finger and attended occupational health. After initial investigation, we were informed the rash had now gone. The other related to a member of staff who complained of a bad taste in the mouth and sore lips. This had not been investigated at the time of interview as it had not been brought to the attention of management, however management now planned to investigate. Both of these may not be related to the introduction of these products.

The nursing staff at NHS Dumfries and Galloway provided limited feedback. They reported no safety issues and stated that they felt they received the same standards of cleaning as normal throughout the trial as they would normally receive.

The project relied on the laundry service delivering the desired quantities to three locations in Scotland. Although the Skegness company were very good, the distance of the laundry site from the trial hospitals presented the trial with additional challenges which if the laundry site had been nearer would have greatly reduced the Project Managers concerns around laundry supply and increased the margin for error. Additional sets of UMF had to be placed in the trial system because of the distance the products were travelling to be laundered. The Project Manager would recommend that any future trials UMF products be laundered and dosed in a location close to the trial hospital.
However, this should only be done if consistency of dosage etc. can be maintained.

In summary, the use of UMF and copper CUWB50 has been identified as bringing some benefits.

These include:

- reduced risk of water spills through no transporting of buckets of water in patient areas, as identified in Aberdeen Royal Infirmary;
- improved cleaning methods; as changing a UMF mop head is less time consuming than returning to a cleaning cupboard to change water as the Aberdeen Royal Staff identified;
- less time to set up mopping systems as UMF with copper arrives after laundry pre dosed, UMF with water is likely to require to be prepared for use locally, this was identified through discussions at NHS Dumfries and Galloway;
- Aberdeen Royal Infirmary highlighted that the floors were drier after cleaning with UMF and water verses the current traditional systems;
- the UMF equipment adjusts to the height of Domestic Staff member, as raised at Aberdeen Royal infirmary, employees identified they had less back and neck strain;
- less cross contamination during transport, as the Laboratories have identified that copper has bacteria killing properties, there is a greatly reduced risk of cross contamination within the hospital from the point of cleaning and collection of bacterial to the point of laundering the UMF;
- at Woodend Hospital, Domestic Staff reported comments that surfaces visually looked cleaner when used with UMF and CUWB50;
- at Woodend Hospital there were comments that copper makes UMF glide and cleaning becomes easier.

Analysis of the Microbiological Testing of Copper CUWB50 and UMF at NHS Dumfries and Galloway

The study at NHS Dumfries and Galloway was designed to test the effectiveness of ultramicrofibre cloths (UMF) with and without a copper biocide solution at removing bacteria from a variety of surfaces in three rooms in Wards (7, 10 and 18) and a treatment room in Accident and Emergency (AE).

The main findings are contained in the main body of this report. Defined sites within the clinical environments were repeatedly sampled for microbes before and after cleaning. The sampling format was designed to assess:

- the presence and number of any and all live microbial colonies recovered from the sampling sites. This is termed Total Viable Counts (TVC);
- the presence and number of methicillin-resistant Staphylococcus aureus (MRSA) and spores of Clostridium difficile (C. difficile) within this TVC population.
Study Protocol and Design

The trial protocol was designed by contributors from NHS Dumfries and Galloway, HFS, UCLH and the Project Board. For reasons outlined the figures from NHS Grampian were not used. The trial started in January 2008 and lasted for 7 weeks as shown in the time plan in Table 1.

<table>
<thead>
<tr>
<th>Test areas</th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
<th>Week 5</th>
<th>Week 6</th>
<th>Week 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>AE</td>
<td>UMF + water</td>
<td>UMF + Cu biocide</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Ward 10</td>
<td></td>
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</tr>
<tr>
<td>Ward 7</td>
<td>UMF + Cu biocide</td>
<td>UMF + water</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Ward 18</td>
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</tr>
</tbody>
</table>

Table 1 - Trial time plan

Microbiological sampling was undertaken on Monday, Wednesday and Friday each week at 1 hour before cleaning, 1 hour after cleaning and 4 hours after cleaning. The sampling sites are available in the NHS Dumfries and Galloway Protocol.

The rationale for the study, inclusion and exclusion criteria for test areas etc, the cleaning methodology, microbiological laboratory methods, statistical methods and outcomes of the study are all described in detail in Appendix 2.

Results

An initial assessment of the raw data necessitated the removal of organism-specific (MRSA and C difficile) data from separate analysis, as their incidence was too low in both arms of the study to allow an appropriately powered statistical analysis. Accordingly, only the TVC data were subjected to detailed statistical analysis.

An example of one day's raw data from Ward 10 is shown in Table 2. TVC, MRSA and C. difficile sampling was performed 1 hour before (-1), 1 hour after (+1) and 4 hours after (+4) cleaning. No MRSA or C. difficile were isolated. A wide range of TVC were detected ranging from 7 to >100. In our analysis of the data all >100 reading (2% of all readings) were taken as 100. In some cases sampling did not take place (NT = not tested; 3.9% of all readings) and reasons were noted – in this case the patient was in the chair thus preventing sampling.
A comprehensive statistical analysis of the data was performed by Dr Coen at UCLH on behalf of HFS. Dr Coen received the whole dataset and was informed of the timelines for the several arms of the study, but was blinded to the nature of all the intervention types. A full set of these analyses is included in Appendix 3. The key findings are presented and discussed below.

Preliminary analysis demonstrated that the overall distribution of TVC numbers was skewed to the right (see Figure 9 as an example), mandating the use of median (as opposed to mean) TVC values in order to better assess central tendency.

Figure 3 shows that the floor sites were the most contaminated, at most times. There are considerable differences in TVC levels detected at the various sampling sites, with the soap and towel dispensers being the least contaminated sampling sites.
The results show pooled median TVC numbers at each sampling site in AE and Wards 7, 10 and 18. Sampling time refers to hours before/after cleaning with UMF with added water or copper biocide.

Figure 3: Effect of Sampling Site on TVC

Figure 4 shows that AE tended to be the least contaminated of the test areas when the combined TVC from all sampling sites were taken together and compared. Retrospective analysis to explain this difference revealed that floors in the 3 wards, but not A and E, were sampled close to a toilet and a sink. The A and E sample areas were usually dry. In addition, AE rooms are cleaned more frequently than rooms on wards. We cannot conclude which of these possible interpretations is correct without further work. No differences reached statistical significance.

The results are for the pooled TVC detected at 10 sampling sites in AE and the 3 Wards.

Sampling time refers to hours before/after cleaning with UMF with water or copper biocide.

Figure 4: Effect of Test Area on TVC

Figure 5 shows that the total combined set of TVC on the three different cleaning and sampling days were similar, although the pre-clean and 1 hour after cleaning TVC median values on Fridays were significantly lower than those found on Mondays, perhaps as a result of reduced cleaning at weekends and/or cleaning on the preceding Monday and Wednesday.
The results are for all 10 sampling sites in AE and the 3 Wards pooled together.

Sampling time refers to hours before/after cleaning with UMF + copper biocide.

NS = not significant.

Figure 5: Effect of Cleaning Day on TVC

Figure 6 shows the effect on median TVC values when the 4 test areas were cleaned with UMF + water compared to cleaning with UMF + copper biocide. The UMF + copper median TVC values are significantly lower than UMF + water at all time points.

The reduced median TVC value before cleaning with UMF + copper biocide compared to UMF + water appears to be the result of a residual effect of copper on bacterial survival in the test areas between cleaning days. The steeper line from t-1 to t+1 seen with UMF + copper biocide vs. UMF + water cleaning suggests the existence of an immediate effect of the copper biocide on reducing detectable TVC at the sampling sites after cleaning.

Figure 6: Effect of Cleaning With UMF + Copper Biocide on TVC
**Figure 7** shows the effect of cleaning with UMF + water vs. UMF + copper biocide on the overall distribution of TVC values at 1 hour before (a) and 1 hour after cleaning (b) and 4 hours after cleaning (c).

The distribution of TVC values is shifted to the left (lower values) 1 and 4 hours after cleaning compared to 1 hour before cleaning.

The UMF + copper biocide TVC values are shifted more to the left (lower TVC values) than the UMF + water TVC values. This shift is reflected in the median TVC values for UMF + water t-1, t+1 and t+4 = 26, 17 and 14 vs. 21, 9 and 10 for UMF + copper biocide respectively as shown on the graphs.

These results confirm those shown in **Figure 6** where cleaning with UMF = water leads to a reduction in TVC at 1 and 4 hours after cleaning.
Figure 7: The effect of cleaning with UMF + water vs. UMF + copper biocide on the overall distribution of TVC values

Figure 8 shows the median TVC for UMF + water and UMF + copper biocide plotted for each cleaning day and for each sampling time (1 hour before and 1 and 4 hours after cleaning). The data show highly variable median TVC values in the first 2 to 3 weeks of the study. This variation receded somewhat in weeks 4 to 7, particularly when UMF + copper biocide was used for cleaning and TVC sampling was at 1 hour before and after cleaning.

Also notable was the lower overall median level with UMF + copper biocide than UMF + water during this latter period. Sampling at 4 hours after cleaning shows increased variability of median TVC particularly in the case of cleaning with UMF + water.

These results suggest that comparative cleaning studies should be conducted over a minimum period of 2 to 3 weeks in order for the initial variability in TVC to stabilise. The reason for this variability is not clear at present, but it could be attributable to either the beneficial effect of UMF when introduced into a test area where UMF were not previously in use and/or improved consistency / effectiveness of use of UMF cloths by the cleaning staff over time.
Report on the Operational trial Microfibre and Copper Trial in a Healthcare Setting

Multivariate analysis was used to calculate the various effects of cleaning while at the same time control for the confounding effects of test area (ward and site), day and week of cleaning, cleaning with UMF + copper biocide – amongst others.

This technique allowed trials to reach further general conclusions in the face of a complex study design.

Figure 9 shows a schematic representation of the three cleaning effects which were able to be inferred from the data, as they relate to the relationship between cleaning and median TVC levels.

Two of these effects relate to cleaning 1) without, and 2) with, copper.

The third effect relates to a significant drop in pre-cleaning levels in the copper arms of the study. This may relate to residual copper in the hospital environment.

Figure 8: The effect of cleaning with UMF + water vs. UMF + copper biocide on the median TVC for each cleaning / sampling day over the 7 week study period.
The graph reveals the residual effect of copper biocide and the additive effect of copper biocide on “immediate” UMF cleaning assessed at 1 hour after cleaning.

The overall reduction in TVC using UMF + copper biocide is 57.9% vs. 30.2% using UMF + water.

**Figure 9: Multivariate analysis of TVC 1 hour before and 1 hour after cleaning with UMF + water or UMF + copper biocide.**

Multivariate analyses showed that the overall drop in TVC levels resulting from cleaning with UMF + water was 30.2% (p < 0.001) when comparing 1 hour after cleaning to 1 hour before cleaning. The effects of cleaning with UMF + copper biocide can be separated into the “residual” (21.7%; p < 0.001) and the “immediate” (23.0%; p = 0.006) effects that together represent a total additional 39.7% reduction in TVC levels and a total TVC reduction of 57.9%. Further analyses indicate that a 2-week period of cleaning was required to develop the residual effect of UMF + copper biocide cleaning.

**Figure 10** shows the effect of switching from UMF + water to UMF + copper biocide cleaning and vice versa in weeks 1 to 3 of cleaning and weeks 4 to 7 of cleaning. There is a significantly lower level of TVC in the first 3 weeks when UMF + copper biocide is used for cleaning and this effect is lost when cleaning changes to UMF + water. The inverse is seen when cleaning with UMF + water in the first 3 weeks is switched to cleaning with UMF + copper biocide resulting in a highly significant reduction in TVC in weeks 4 to 7. These results show that cleaning with UMF + copper biocide is more effective than UMF + water and that the residual effect of the copper biocide is lost over a short period of time if it is not regularly used.
Multivariate analyses were used to calculate the effects of switching cleaning from UMF + water to UMF + copper biocide and vice versa.

Figure 10: The effect of switching from UMF + water to UMF + copper biocide on TVC levels.

Discussion

The NHS Dumfries and Galloway Royal Infirmary 7 week cleaning study compared the effects of UMF cloths with water or impregnated with a copper biocide solution on microbial contamination (as total viable counts: TVC) in 4 test areas (AE and 3 wards) at a total of 13 sampling sites (10 per test area). Sampling was undertaken 1 hour before and 1 and 4 hours after cleaning of the test areas. The study has produced a total of 2421 TVC data points distributed into a time-series design with sites nested within wards - that required expert statistical analysis.

The following discussion of the results focuses on more general conclusions arising from the statistical analysis of the data.

It is important to reiterate that the specific microbiological sampling for MRSA and C. difficile at NHS Dumfries and Galloway unfortunately yielded very low and erratic counts that did not merit analysis. However, TVC are a more useful measure of bacterial contamination in hospital Wards and also a useful way to assess the effects of cleaning regimes on bacterial contamination as demonstrated in recently published studies (Cooper et al. American J Infection Control 35:338-341, 2007; White et al. International J Environmental Health Research 17:285-295, 2007).

Over the whole 7 week cleaning study period, there was considerable variability in TVC detected at the 13 different sampling sites (Figure 3), with the floor sites generally being the most contaminated. Of the test areas, AE was found to be somewhat less contaminated than the 3 wards especially at 1 hour before and after cleaning (Figure 4). Cleaning took place daily and swabbing took place on Monday, Wednesday and Friday each week and the lowest median TVC levels were found to be on Fridays, particularly at 1 hour before and after cleaning (Figure 5).

When cleaning with UMF + water was compared to cleaning with UMF + copper biocide over the 7 week period of the study, the statistical analysis revealed a
Clear beneficial effect of UMF + copper biocide in terms of significantly reduced TVC detected at all time points before and after cleaning (Figure 6). This analysis gave the first indication that UMF + copper biocide was having 2 different effects - an immediate effect that resulted in a greater reduction of TVC 1 hour after cleaning than cleaning with UMF + water and a residual effect of reducing TVC levels that is evident at 1 hour before cleaning.

The immediate effect of UMF + copper biocide cleaning is most evident at 1 hour after cleaning and this is demonstrated in Figure 7 where the distribution of TVC intervals is plotted. It can be seen that the median TVC values are lower at all time points when cleaning with UMF + copper biocide is compared to cleaning with UMF + water.

When the median TVC for UMF + water and UMF + copper biocide are plotted for each cleaning day and for each sampling time (1 hour before and 1 and 4 hours after cleaning), it can be seen that in the first 2 to 3 weeks of the study the median TVC values were highly variable (Figure 8). However, in weeks 4 to 7 of the study the median TVC levels became less variable, particularly in the case of UMF + copper biocide and the general median level was lower with UMF + copper biocide than UMF + water. These effects were most evident 1 hour before and 1 hour after cleaning. These results gave the first indication that comparative cleaning studies should be conducted over a minimum period of 2 to 3 weeks. This conclusion is particularly important when considering the cleaning studies that were conducted at Woodend Hospital and the Aberdeen Royal Infirmary both in NHS Grampian.

Further multivariate analyses of the data from the whole 7 week study period were performed, and allowed the trial to demonstrate and differentiate more clearly the dual beneficial effects of cleaning with UMF + copper biocide vs. UMF + water. As shown in Figure 9, the median TVC level before cleaning was significantly reduced when UMF + copper biocide was used. Median TVC levels 1 hour after cleaning comprise a cleaning effect of UMF + water and an additional immediate effect of cleaning with UMF + copper biocide.

Further multivariate analyses showed that the overall drop in TVC levels resulting from cleaning with UMF + water was 30.2% when comparing 1 hour after cleaning to 1 hour before cleaning. The dual effects of cleaning with UMF + copper biocide were also quantified using the same multivariate analyses comparing 1 hour before and after cleaning; the residual effect of the copper biocide resulted in an overall 21.7% reduction in TVC levels over the 7 week study period and the immediate effect resulted in an overall 23.0% reduction in TVC over the 7 week study period. Therefore, the total effect of UMF + copper biocide cleaning results in a 57.9% reduction of TVC levels over the 7 week study period. This figure is an underestimate of the UMF + copper biocide effect because further multivariate analyses revealed that the residual effect of the copper biocide requires approximately 2 weeks of cleaning to become fully evident.

It was also clear that switching from UMF + copper biocide cleaning to UMF + water cleaning results in a loss of the beneficial effects of copper biocide in reducing TVC levels as shown in Figure 10. The inverse - switching from UMF + water cleaning to UMF + copper biocide led to immediate and significant
reductions TVC levels from both wards. These results show that cleaning with UMF + copper biocide reduces TVC more effectively than UMF + water and that the residual effect of the copper biocide is lost if it is not used. The important conclusion is that copper biocide must be used regularly if its benefits are to be maintained. It will be important to determine whether or not the residual effect increases further with continued use of UMF + copper biocide over longer periods of time.

Another benefit of UMF + copper biocide cleaning that was not directly assessed during this study is that UMF containing copper biocide at concentrations of 150 ppm or higher (300 ppm was used in the present study), will inactivate bacteria picked up during cleaning within a period of 30-60 minutes. This is an extremely important additional benefit when one considers that bacteria picked up by UMF cloths with water alone remain viable for at least 16 hours after cleaning (Gant et al. J Antimicrobial Chemotherapy 60:294-299, 2007).

Dr Reid NHS Grampian and Dr Galloway (Redsox Research Ltd) also reviewed the Dumfries and Galloway results. One of their principle findings related to the use of UMF and copper CUWB50 and the impact on TVC levels was used together they give rise to significantly lower TVC levels compared with 'standard clean.

Dr Vanya Gant of UCLH also reviewed the NHS Dumfries and Galloway results and found the use of UMF with CUWB50 reduced the TVC in the hospital environment.
Conclusions from the NHS Dumfries and Galloway and NHS Grampian Operational Study

- planning of trials and site preparations are essential. Plans/protocols should be set agreed and not changed;
- operational consistency and quality control is vital throughout the trial;
- training and confidence in the UMF products had a major impact in the outcomes of the trial;
- leadership and communication is key to trial success sites, examples of strong operational supervisory and management teams were observed within trial locations where within the same areas the Domestic Staff also appeared more engaged with the process providing the most positive feedback on their involvement and sharing their operation views on the trial success;
- Domestic Staff found the UMF system easy to use; staff found the equipment reduced back and neck strain and when used with water it reduced the requirement to move and exchanged large quantities of dirty water;
- no safety issues were reported at NHS Grampian or NHS Dumfries and Galloway, although indirect comments were raised at Project Managers meetings which the local management team required to trial;
- a high percentage of Domestic Staff felt if the UMF was pre dosed prior to their receipt, they would spend less time setting up the cleaning trolley at the start of every shift;
- a number of Domestic Staff felt the UMF with copper cleaned better; they commented on the increased soil on the UMF, they also felt the product glided as it cleaned;
- the known copper CUWB50 bacterial killing properties will assist in reduction cross contamination as the UMF is transported from the area of cleaning to the laundry;
- laundry responsibilities with a third party ensure the complex laundry requirement are delivered and maintained throughout the trial;
- laundry sites should be located closer to the point of UMF use to allow for operational error and reduce the logistical complexities;
- cleaning with UMF significantly reduces TVC on the test surfaces by 30.2%. TVC reduction is significantly further enhanced with addition of copper biocide to 57.9%;
- MRSA and C difficile were very rarely isolated, making reliable statistical analysis specific to these two organisms impossible.
The copper biocide has 2 separate effects:

- an immediate antibacterial effect that is most evident shortly after cleaning;
- a residual antibacterial effect that appears approximately 2 weeks of cleaning to establish, and seems to confer longer term protection. This longer term protection requires regular application if it is to persist.

**Recommendations**

- the results from this first study demonstrate encouraging and impressive microbiological cleaning performance for UMF, which is further enhanced with copper biocide;
- further trials are recommended to validate and extend these findings in other healthcare settings; these should include cleaning periods of at least 3 weeks for each component; the hospital selected should be selected as one which has had a history of increased levels of contamination with MRSA, C difficile, or both. In vitro data suggest that copper is highly biocidal to MRSA, and is also either sporicidal for C difficile, or is capable of preventing successful germination. This selection criteria would allow for the specific analysis of these cleaning technologies on two organisms very highly relevant to hospital acquired infection;
- these studies should be designed to provide necessary further evidence on the relative contributions of microfibre and copper to the overall cleaning process. In addition, be designed to provide the necessary broader evidence base before possible widespread implementation. These should include questions of optimal logistics for microfibre regeneration and supply, optimal cleaning and biocide protocols for maximum antibacterial effect and optimal environmental mitigation strategies for copper biocide;
- the hospital selected should have a local laundry which can comply with the copper CUWB50 storage, laundry, recycling and dosing;
- the longer trial period will also head off any potential hawthorn effect;
- in order to identify if the widespread introduction of copper CUWB50 and UMF would be feasible a full cost benefit analysis needs to be undertaken in any further phase of this study;
- the development of education and training protocols for staff in the use of these products would further enhance the performance within future trial locations.
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The Dumfries and Galloway Infirmary (DGRI) hospital cleaning study comparison of the performance of ultramicrofibre technology with or without addition of a novel copper - based biocide Corresponding author Department of Microbiology, University College Hospitals NHS Foundation Trust.

Protocol References


A comparative study of microfibre alone versus microfibre and copper solution and standard hospital cleaning procedures versus microfibre alone. Dr Tom Reid, Mr Alex Wilson and Dr DG Galloway, December 2007. Protocol number: Microfibre/hospital (version 4 17/12/07).
Appendix 1

Domestic Staff comments from NHS Dumfries and Galloway and NHS Grampian

"UMF Mops left a streaky finish although they have a streaky finish at the moment";

“The UMF trolley took a long time to set up”;

“Our nursing did not pass any comments”;

“UMF mops dried out of copper but did not tell my supervisor”;

“I did not see a difference in the UMF mops with water from current I use with detergent”;

“Folding the cloths took time”;

“The cloths moved out of shape with use”;

“Our nurses were not happy there was no cleaning smell”;

“The UMF trolley I had was to small”;

“I needed more training from the UMF company”;

“I don’t normally have a dry mop with the UMF system I use it was excellent”;

“Our mops are normally wet when they arrive, it was time consuming to wet mops that made the set up before cleaning was too long”;

“I was aware another domestic said she had a bad taste in her mouth I don’t know if it was reported”;

“When I wore disposable gloves the gloves turn yellow when I used copper”;

“No surfaces were stained”;

“Much easier to use than our current UMF system”;

“The trolley was too small the mobility of trolley was good”;

“There was no slippy floors after copper”;

“A Dr. passed comment there was a metallic smell in the air”;

“We were surprised to find that using the dry mop and the wet mop did not take any longer than just using the wet mop as do at the moment”;

“We preferred the wet and dry mop to our current UMF mop”;
“The system was excellent used with copper or water”;

“There was little difference in time from the current system to using the full cloth and mop systems with water or copper”;

“System was easier to use my neck and back did not hurt”;

“The system when you used it with copper seemed to glide”;

“The UMF seemed to pick up more debris when the copper was used with it”;

“The floor was not streaky”;

“The UMF mopping system was much better than our flat mops”;

“I did not like the UMF cloths although I did like the mops”;

“The system UMF was very good”;

“I rate the UMF mops high and the UMF cloths very low”;

“The cloths were difficult to use folded, I prefer a bundle”.

Appendix 2

Protocol

for

A Comparative Study Of Ultra Microfibre Alone Against

Ultra Microfibre Impregnated With Copper Solution.

Dumfries and Galloway Royal Infirmary 12 2007

Dr Dave Hamilton
MBChB, MRCP, MRCPATH, BSc
Consultant Microbiologist,
Dumfries and Galloway Royal Infirmary
Speciality Team Lead, Microbiology
1. **SIGNATURES**

The investigators and the sponsor have discussed this protocol. The investigators agree to perform the investigation and to abide by this protocol except in the case of medical emergency or where departures from it are mutually agreed in writing.

**Investigational Site**

**Principal Investigator**

Dr Dave Hamilton Consultant
Microbiologist Dept of Microbiology
Dumfries and Galloway Royal Infirmary

Signature     Date

**Co-investigators**

Adelle Foster Biomedical Scientist, Microbiologist
Dept of Microbiology
Dumfries and Galloway Royal Infirmary

Signature     Date

Raymond Mundel,
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Microbiologist Dept of Microbiology
Dumfries and Galloway Royal Infirmary

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Email: lynn.ballantyne@fmspecific.co.uk
3. INTRODUCTION

The hospital environment plays an important part in cross-infection [reference xxi]. The complex nature of the care environment provides multiple ecological niches for pathogenic microorganisms to colonise or at least survive [Reference xx]. MRSA, often on skin squames, can survive in dust on surfaces for many days. Increasingly the role of the environment as a source of *C. difficile* is also being recognised [reference xxiii]. The other organisms that can cause cross infection can be removed and the risk reduced by careful good quality environmental cleaning [reference (xxii)]. Microfibre materials have been found to make a significant difference to the effectiveness of such cleaning [reference (xxiv)]. There is evidence that impregnating microfibre with agents such as copper can enhance this effectiveness further.

Infection with methicillin-resistant *Staphylococcus aureus* (MRSA) and other infection has become endemic in hospitals around the world despite concerted efforts by infection control professionals [Reference (i)].

In the UK the proportion of blood isolates of *S. aureus* that are resistant to methicillin has risen from just a few percent in the late 1980's to well over 30%, with rates of over 40% seen in tertiary referral hospitals [References (ii) to (iv)]. Similar prevalence rates are reported from other European countries [Reference (iv)] and from the US [Reference (v)].

It is particularly disturbing that *S. aureus* is the commonest cause of surgical-site infection in British hospitals and more than half the infecting strains are methicillin resistant [Reference (vi)].

Nearly all MRSA infections are acquired in hospital and many of them are potentially preventable [Reference (vii)].

Although much attention has been placed on the rising tide of patient to patient and staff to patient infections within the hospital environment, it is well documented that many other strains of infecting organisms, including those of fungal and viral origin, are available within a hospital environment and are readily transmitted between patients.

Much effort therefore in the past 20-30 years has been placed on the implementation of standard infection control practices but the widespread failure to control MRSA in particular is quite striking [Reference (viii)].

In more recent years, hospital design and hygienic practices have been largely directed at controlling *S. aureus* contamination of air, hands, instruments and services. Indeed, by the late 1970's these practices had been so successful that the hospital environment was considered to make little contribution to the spread of hospital infection [References (ix) and (x)].

Recent events however have indicated that standards of hospital cleaning have declined and floors, furniture and medical equipment may now be sources of MRSA and other infectious agents [References (xi), (xii) and (xiii)].

Current guidelines for the control of MRSA in UK hospitals recognise the potential importance of the environment and recommend terminal cleaning of isolation rooms after patient discharge [Reference (iii)]. In practice, manual cleaning of complex environments containing beds, furniture, medical equipment and soft furnishings is difficult [Reference (xiv)].

Similarly the rising incidence of *C. difficile* infection in hospital has caused considerable anxiety at a Governmental level, Hospital Trust level, managerial level and, of course, in patients. This potentially lethal organism causes significant illness in vulnerable patients, especially the elderly and those in a post-operative, debilitated state such that new measures are being evaluated in order to combat this particular organism.
Much like MRSA, the detail of hospital deaths which include *C. difficile* as a contributory factor to patient death has given much cause for concern. There are effective and well documented antibiotic therapies available for their treatment. Nonetheless, in those who are either frail or immuno-compromised or both particularly, reports of outbreaks with significant mortality are increasing.

As one initiative in combating both the rise of MRSA and *C. difficile* in hospital wards, the introduction of microfibre technology both in the form of floor mops and hard surface cloths, has been found to be effective in cleaning environments in which Hospital Acquired Infections both develop and flourish.

As an additional component towards the reduction of both organisms but particularly *C. difficile*, recent studies at University College Hospital London (UCLH) have indicated that in the laboratory the combination of microfibre technology (both in mop and cloth format) coupled to a copper containing solution, has added to the elimination of both MRSA and *C. difficile* [Reference (xvi)] [Appendix 3, MSDS]. Their methodology, technology and application of the combination of microfibre and copper solutions have been well documented in the laboratory at UCLH and has been found to be particularly useful as a concept whereby reduction in the spread of such Hospital Acquired Infections without adverse effects to people, equipment and environment, are in place [Appendix 3, Aberdeen protocol].

The combination of microfibre technology and copper solutions may fulfil in due course the appropriate COSHH requirements. Microfibre, of course, has been in use for a number of years and has been found to be effective both as a floor and hard surface cleaner in its own right and has been widely used in the NHS.

Microfibre has been found to eliminate cross infection from bacteria, fungi and viruses and may be more effective in the clinic, hospital or Ward or other public areas where HAI is a demonstrable threat to the patient based population.

The establishment of microfibre technology in hospital environments is now widespread in some countries and the detail for the use of such technology has been well documented.

Further, the use of a copper solution in a variety of formulations and strengths has also been evaluated both in the UK and elsewhere. Referenced documentation to published research on the additive value of copper solutions to microfibre technology is available.

A Materials Safety Data Sheet has been prepared for the copper solutions and is available for all product supplies (Appendix 3).

The physical chemical properties of the copper solution have been evaluated by the host company [Appendix 3]. In particular, the assessments for *C. difficile* spores are detailed in the research reports [Reference (xvii)] and in broad terms evaluate the following key features:

a) Heat resistance of *C. difficile* spores  
b) Residual activity of purell and copper biocide gels  
c) Survival counts at different time-points

It is concluded that the active copper component within the formulation does not pose a risk to human health or the environment [Appendix 3, MSDS].

There is evidence that microfibre technology can be used as an effective alternative to other cleaning agents for hard surface disinfection already in use in clinical practice (Appendix 4).

The addition of a copper based solution (at 150 ppm) using the preferred formulation CuWB50 has a number of other attractive features. It is prepared, ready to use in fixed
dilutions by Remedy Research Ltd at its service facility based in Glasgow. It is therefore consistent and convenient, reducing preparation and emergency response time in the event of any accident using the solution. It has been evaluated in contact with a number of different surfaces and may be compatible with a range of fabrics, rubbers, plastics and hard surface materials.

It is an effective disinfectant and cleaner in one step and hence, by use of its copper characteristics, saves both time and eliminates the need for multiple products, separate storage and extensive training.

The copper solution associated with microfibre technology is non-corrosive and non-irritant and in addition is non-flammable and has been designed to be safe on human tissue. It has an established shelf life with sustained efficacy and no special waste treatment is required in the dilutions used (150 ppm) in its disposal following normal use where use of a standard chelating disposal unit is associated with the effluent from an appropriate modified Electrolux washing machine with appropriate supervision.

The combination of microfibre and copper solutions has been shown to be effective against a range of organisms in in vitro studies and in particular, MRSA and C. difficile, with contact times varying between 15 minutes and 960 minutes [Reference (xvii)].

The protocol for the use of microfibre and copper solutions in healthcare facilities has been developed following extensive laboratory investigation and is appropriate for any non-porous surface.
4. RATIONALE

Much concern has been expressed in recent years on the increasing need for topical hard surface decontamination for hospital and related facilities where patient care may be compromised by the presence of either bacterial, fungal or viral infection.

The rationale of using a topical hard surface disinfectant is that where use of the agent has been found to be effective and indeed lethal to a range of organisms on direct contact, then such an agent at 15 minutes could be a major introduction to hospital and related hard surface environments in the reduction and spread of surface to surface and surface to person spread.

Microfibre technology allied with a copper solution (CuWB50) is being evaluated for use in the laboratory setting as a generalized disinfecting cleaner suitable for a variety of applications in hospitals, General and Dental Practices, schools, kitchens, and homes for the elderly or disadvantaged and many other related uses.

The object of the present pilot study is to establish the disinfectant/antibacterial efficacy of microfibre and a copper solution in combination in reducing microbial load in the environment, specifically a reduction in MRSA and *C. difficile*. Such UK based evidence of efficacy, may promote its introduction to the NHS in the UK in both hospitals and other healthcare practices as a one-stop surface antibacterial.

5. INCLUSION CRITERIA

1. Single-bed rooms or single bed space areas within wards 7, 10 and 18, and a major trauma room in A+E have been identified within the hospital. These rooms are representative of the areas where contamination with MRSA and/or *C. difficile* are a particular risk and where cross infection has previously been suspected.

2. The test area should be part of the usual hospital cleaning routine and should be known and familiar to the microbiologist.

3. The cleaning personnel should be the same throughout the study.

4. All staff (including Domestic Staff) need to be aware of the requirements of the study related to MRSA and *C. difficile* decontamination.

The Wards will be swabbed in designated areas three times a week by a Biomedical Scientific Officer (BSO) who will also take responsibility for culture and test results. In her absence the Consultant microbiologist will assume responsibility. The contact plates will be collected pre-cleaning and 1 and 4 hours post cleaning in each area. Once collected the plates will be transferred directly to the Microbiology Laboratory.

The rooms/Wards will be cleaned by the same staff used throughout the exercise at the same times of day for the same periods of time. All other aspects of routine cleaning will be unaltered throughout the trial.

6. EXCLUSION CRITERIA

1. Cleaning personnel will be required to sign each day when routine cleaning is completed within the study ward areas. This documentation will be checked prior to sampling and if absent and cleaning has not been undertaken sampling will be abandoned that day.

2. Addition of other cleaning agents during the course of the trial will not be acceptable.
3. Sampling will not be undertaken, of the results not included if infection control issues require that a different chemical is used such as Hypochlorite, or where preparation (other than cleaning) of the room or Ward area is undertaken for purposes not compatible with the clinical trial design, e.g. redecoration.

7. STUDY DESIGN

7.1 Cleaning methodology

The study design is summarized in the flow diagram (Appendix 1).

The use of microfibre mops has been part of the established practice in Dumfries and Galloway for several years. The present study is designed to compare the total microbial load and that of MRSA and *C. difficile* in particular in three wards and one units in Dumfries and Galloway Royal Infirmary, the principal Acute unit in Dumfries and Galloway. Microfibre cleaning of non floor surfaces is not normal practice but will be introduced prior to the study.

The study will begin with two wards being randomized to start with microfibre alone and the remaining two with microfibre and copper. After three weeks of continuous use the two methods will be reversed for a further three weeks. A two week washout period is proposed for the units where copper was used in the second three week timeframe. Domestic staff and those undertaking microbiological sampling and examination will be blinded to which method is in use where. All other cleaning methods and materials will be unaffected and the same across all four units.

Microfibre mop and cloth cleaning techniques will be used throughout the study under supervision and the same Wards and contact points will be used as well as the same BSO dedicated to this aspect of the work.

Cleaning of the test rooms will be undertaken at the same time of day whenever possible. When clinical issues prevent this, the domestic will inform the domestic supervisor who will ensure the laboratory is informed. Where a substantial delay is likely testing may be delayed 24 hours. Otherwise Monday, Wednesday and Friday will be the test days.

In each of the two arms of the test protocol, the trial will establish a baseline for the microbial load in the selected test areas using the current cleaning procedures without changes to the procedures, products or staff other than specifying the time at which the rooms should be cleaned.

7.2 Laboratory methods

The laboratory staff undertaking the testing, resulting and data analysis will not know which ward is under test and which is a control. The Domestic Supervisor and her deputy will alone decide the groupings.

The test area will be swabbed at 10 points according to a pre-determined plan, [Appendix 2] pre-cleaning 1 and 4 hours post-cleaning on each of 5 days in the designated weeks by arrangement with the individual Wards. The order of sampling each site will be: nutrient agar, MRSA, *C. difficile* plate. The swabs will be assessed for total viable counts (TVC) and the presence of MRSA and *C. difficile* organisms.

The study will be supervised in each of the selected rooms or hospital areas by a qualified, experienced, dedicated Microbiologist or his designated assistant. Responsibilities for selected swabbing points will be defined on a pre-determined sheet (Appendix 6) and will cover both hard and soft surfaces which are susceptible or common to hand touch.
The investigating Microbiologist or his designated assistant will be the same throughout the study.

Collection of samples will be as described in appendix 2. All samples will be incubated at 30°C for 48 hours in air. Enumeration of the number of colonies for total viable count will be undertaken using the nutrient agar plate. The MRSA plates (Brilliance MRSA Contact Plates, Oxoid UK) and C. difficile plates (Braziers with Lysozyme, Oxoid, UK) will be examined for colonies suggestive of MRSA and C. difficile respectively. Full identification will be undertaken using standard methods as described in the national SOP’s.

7.3 Statistical analysis

Evaluation of the study will be by comparison of TVC and the presence of MRSA/C.difícile in all individual rooms and hospital areas involved in the study. This will be done by simple data comparison (t-test) and will also involve the comparison of log reductions in bacterial counts.

Initial scoping cultures were used to compare our colony forming unit (CFU) results with those of the Aberdeen results. These found ours to be lower but not significantly so. On this basis we will proceed with the same statistical analysis of results. The scoping cultures were taken one hour after microfibre cleaning when CFU counts would be expected to be at their lowest compared to the other sampling times of prior and four hours post cleaning. The results of the pilot study together with the calculations associated with that are included as part of the statistical design and rationale for the present definitive study.

8. OUTCOMES

The outcomes of the study will be as follows

1. Any differences in the total viable count (TVC) between the use of microfibre alone or microfibre and copper solution in the individual rooms or test areas.

2. Any differences in episodes of isolation of MRSA and C.difícile in each location will be identified.

3. Any difference between the two microfibre cleaning systems when used alone and with copper impregnation will be identified.

Acknowledgement:

This protocol is based on that produced by Dr. David Galloway and Dr. Tom Reid for the Aberdeen arm of this trial. They are also to be thanked for arranging the statistical analysis.
## Appendix 1

### Copper Impregnated Mopping

DGRI  
2008

### Trial Time Plan

<table>
<thead>
<tr>
<th>Ward</th>
<th>Week</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
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<tbody>
<tr>
<td>A</td>
<td>Vikan</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Vileda</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Vikan</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td>Vileda</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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Trial 

Control 

Week 

1 2 3 4 5 6 7 8
## Appendix 2

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<th>Ward 9</th>
<th>Ward 18</th>
<th>A+E</th>
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<td>Floor at entry</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>Floor by bed</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Bin lid</td>
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<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Shelf</td>
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<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
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<td>Chair</td>
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</tr>
<tr>
<td>Alcohol dispenser</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Floor right corner</td>
<td>✔️</td>
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<td>✔️</td>
<td>✔️</td>
</tr>
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<td>✔️</td>
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<td>Help button</td>
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</tr>
<tr>
<td>Door handle</td>
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<tr>
<td>Cabinet</td>
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<tr>
<td>Floor by toilet</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
</tbody>
</table>
9. REFERENCES:


(xvi) Johnson Diversey microfibre technology.
(xvii) Microbiology Report supplied by UCLH

(xviii) Hall TJ. A Comparison of the biocidal effects of CuWB50 vs. bleach on ultramicofibre cloths on the cleaning of the spores of 3 different ribotypes of Clostridium difficile from laminate surfaces. Initial Hospital Services Project Report: 1-2007


(xx) Dancer, SJ. Importance of the environment in meticillin-resistant Staphylococcus aureus acquisition: the case for hospital cleaning. Lancet Infect Dis. 2007:


Microfibre and copper

Cleaning study
Glasgow, 22 Aug 2008
Pietro G Coen

The design

- On the day
  - Sample at -1 h (*)
  - Clean at 0 h
    (± copper)
  - Sample at +1 h
  - Sample at +4 h

- Sample from ‘sites’
- Sample from wards

(e.g. floor etc)
AE, etc
### Design

<table>
<thead>
<tr>
<th>Week</th>
<th>A/E</th>
<th>7</th>
<th>10</th>
<th>18</th>
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<tbody>
<tr>
<td>1</td>
<td>no copper</td>
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<td>no copper</td>
<td>copper</td>
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<tr>
<td>2</td>
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<td>copper</td>
<td>no copper</td>
<td>copper</td>
</tr>
<tr>
<td>3</td>
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<td>no copper</td>
<td>copper</td>
</tr>
<tr>
<td>4</td>
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<td>no copper</td>
</tr>
<tr>
<td>5</td>
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<td>copper</td>
<td>no copper</td>
</tr>
<tr>
<td>6</td>
<td>copper</td>
<td>no copper</td>
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<td>no copper</td>
</tr>
<tr>
<td>7</td>
<td>copper</td>
<td>no copper</td>
<td>copper</td>
<td>no copper</td>
</tr>
<tr>
<td>Type of surface</td>
<td>Wards</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------</td>
<td>---------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floor entry</td>
<td>All</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floor far right corner</td>
<td>Not AE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floor by toilet</td>
<td>Not AE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floor under sink</td>
<td>All</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Shelf</td>
<td>All</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Patient chair / seat</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Tray</td>
<td>Not AE</td>
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<tr>
<td>Bed end</td>
<td>All</td>
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<tr>
<td>Bin lid</td>
<td>All</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soap dispenser</td>
<td>All</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Floor left corner</td>
<td>AE only</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floor far left</td>
<td>AE only</td>
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<td></td>
</tr>
<tr>
<td>Towel dispenser</td>
<td>AE only</td>
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</tr>
</tbody>
</table>
Baseline TVCs

Median TVC

Sampling ‘site’

Sampling time

Count category

Frequency

Missing data:
26 (no copper) [420]
21 (copper) [420]

Median = 23 (95% CI: 21-24)
Ward (common sites only)

**Day of the week**

**Median TVC**

- Monday
- Wednesday
- Friday

**Sampling time**

- $t = -1\ h$
- $t = +1\ h$
- $t = +4\ h$

**A/E**
- Ward 7
- Ward 10
- Ward 18

NS = not significant

Mon vs Fri
- $p = 0.0005$

Mon vs Fri
- $p = 0.007$

Mon vs Fri
- $p = NS$
Effect of cleaning

Univariate

Median TVC

Sampling time

Median count

-1 h  +1 h  +4 h

Umf + Cu  Umf

NS
**Switching: (+1 h)**

![Graph showing changes in TVC over weeks with statistical significance.]

- **Copper to Normal**: $p = 0.0005$  
- **Normal to Copper**: $p < 0.0001$

---

**Time series**

Large day to day variation in baseline TVCs. More meaningful is the change from baseline to after cleaning.
UMF+water

UMF+water

UMF+water+Cu

UMF+water+Cu

Median TVC

Days

t = -1 h

t = +1 h

t = +4 h

0 10 20 30 40 50

Days

Median TVC

t = -1 h

t = +1 h

t = +4 h

0 10 20 30 40 50
Multivariate analysis

Control for potential confounders

Used Ln(TVC+1) transformation

Variables

- Estimate and control for:
  - Effect of UMF + water
  - Effect(s) of copper
  - site
  - week
  - day of week
  - ward
  - site x ward
  - Copper x ward
Effects of cleaning

- **Direct effect of water**: slope
- **Direct effect of copper**: difference between slopes
- **Residual effect of copper**: difference between intercepts (i.e. pre-cleaning TVCs)

Model parametrization

\[ \ln(TVC) = a_0 + a_1 \cdot t + a_2 \cdot c + a_{21} \cdot ct + \sum_{i=2}^{12} a_{3i} \cdot z_i \]

- \( a_1 \): Effect of cleaning with UMF+water
- \( t = 0 \) (baseline) or 1 (+1 h)
- \( a_2 \): Residual effect of copper (if positive)
- \( c = 0 \) (UMF+water) or 1 (+ copper)
- \( a_{21} \): Additive effect of copper on microfibre
- \( a_{3i} \): 12 effects of site (i = 2 to 13)
Multivariate ANOVA

<table>
<thead>
<tr>
<th>Effect</th>
<th>+1h vs Baseline</th>
<th>+4h vs Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water (direct)</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Cu (direct)</td>
<td>0.048</td>
<td>0.0002</td>
</tr>
<tr>
<td>Cu (resid.)</td>
<td>0.019</td>
<td>0.37</td>
</tr>
<tr>
<td>Site</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Ward</td>
<td>0.013</td>
<td>0.19</td>
</tr>
<tr>
<td>Day of week</td>
<td>&lt;0.0001</td>
<td>0.04</td>
</tr>
<tr>
<td>Ward x site</td>
<td>0.0001</td>
<td>0.0033</td>
</tr>
<tr>
<td>Cu (direct) x ward</td>
<td>0.001</td>
<td>0.022</td>
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Protective efficacy (%)

-1 to +1 h

<table>
<thead>
<tr>
<th>Effect</th>
<th>% TVC drop</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Umf</td>
<td>29.9 (21,39)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Cu (residual)</td>
<td>19.7 (4,33)</td>
<td>0.019</td>
</tr>
<tr>
<td>Cu (direct)</td>
<td>19.3 (0.2,35)</td>
<td>0.048</td>
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<tr>
<td>Cu (res + dir)</td>
<td>35.2 (4,56)</td>
<td>-</td>
</tr>
<tr>
<td>Cu (res + dir) + Umf</td>
<td>54.6 (23,73)</td>
<td>-</td>
</tr>
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</table>

-1 to +4 h

<table>
<thead>
<tr>
<th>Effect</th>
<th>% TVC drop</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Umf</td>
<td>40.4 (32,48)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Cu (residual)</td>
<td>8.0 (-10,23)</td>
<td>0.37</td>
</tr>
<tr>
<td>Cu (direct)</td>
<td>32.8 (18,45)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Cu (res + dir)</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Cu (res + dir) + Umf</td>
<td>63.2 (38,78)</td>
<td>-</td>
</tr>
</tbody>
</table>
### Aberdeen

### Study Design

<table>
<thead>
<tr>
<th>hosp</th>
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<th>0</th>
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<th>1</th>
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<tbody>
<tr>
<td>ward</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
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<table>
<thead>
<tr>
<th>week</th>
<th>16</th>
<th>18</th>
<th>36N</th>
<th>36S</th>
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<tbody>
<tr>
<td>1</td>
<td>umf</td>
<td>+Cu</td>
<td>mops</td>
<td>umf</td>
</tr>
<tr>
<td>2</td>
<td>+Cu</td>
<td>umf</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>umf</td>
<td></td>
<td>mops</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **mops** = currently used flat mops
- **umf** = ultramicrofibre
- **+Cu** = umf + copper
Sites

<table>
<thead>
<tr>
<th>Site</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Over-bed anglepoise light</td>
</tr>
<tr>
<td>2</td>
<td>Over-bed table top</td>
</tr>
<tr>
<td>3</td>
<td>Nurse call hand control</td>
</tr>
<tr>
<td>4</td>
<td>Locker top</td>
</tr>
<tr>
<td>5</td>
<td>Patient chair - seat</td>
</tr>
<tr>
<td>6</td>
<td>Bed - hydraulics</td>
</tr>
<tr>
<td>7</td>
<td>Floor by bed</td>
</tr>
<tr>
<td>8</td>
<td>Floor toilet</td>
</tr>
<tr>
<td>9</td>
<td>Apron/towel dispenser</td>
</tr>
<tr>
<td>10</td>
<td>Electronic control for bed</td>
</tr>
</tbody>
</table>

Aberdeen

- Median
  - $66 \text{ Cu+Umf} \ [100]$
  - $44 \text{ Umf} \ [100]$

- $t = -1h$
- $p = 0.07 \ [BS]$
Aberdeen

P < 0.0001 [ANOVA of ln(TVC+1)]

P < 0.0001 [ANOVA of ln(TVC+1)]

Median TVC

Sample collection

[Graph showing median TVC levels over time for different areas in Aberdeen]

[Graph showing median TVC levels over time for different areas in Aberdeen]
**Aberdeen**

NS = not significant

### Median TVC

**P = 0.71 [NS] [ANOVA of ln(TVC+1)]**

- **Sample**
  - Mon
  - Tue
  - Wed
  - Thur
  - Fri

### Umf + Cu (WE) vs Umf (WE)

- **P = 0.0064**
- **P = 0.033**
Aberdeen: ward 16

Day since trial start

TVC

Um + Cu

Um

Aberdeen: ward 18

Day since trial start

TVC

Um + Cu

Um

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### Primary effects

**-1 to +1 h**

<table>
<thead>
<tr>
<th>Effect</th>
<th>Dumfries &amp; Galloway % TVC drop</th>
<th>p-value</th>
<th>Aberdeen % TVC drop</th>
<th>p-value</th>
</tr>
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<tbody>
<tr>
<td>Umf</td>
<td>29.9 (21.39)</td>
<td>&lt; 0.0001</td>
<td>-</td>
<td>NS</td>
</tr>
<tr>
<td>Cu (residual)</td>
<td>19.7 (4.33)</td>
<td>0.019</td>
<td>-</td>
<td>NS</td>
</tr>
<tr>
<td>Cu (direct)</td>
<td>19.3 (0.2, 35)</td>
<td>0.048</td>
<td>37.7 (8.58)</td>
<td>0.017</td>
</tr>
<tr>
<td>Cu (res + dir)</td>
<td>35.2 (4.56)</td>
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<td>-</td>
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**-1 to +4 h**

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</tr>
</thead>
<tbody>
<tr>
<td>Umf</td>
<td>40.4 (32.48)</td>
<td>&lt; 0.0001</td>
<td>30.1 (10, 46)</td>
<td>0.005</td>
</tr>
<tr>
<td>Cu (residual)</td>
<td>8.0 (-10.23)</td>
<td>0.37</td>
<td>-</td>
<td>NS</td>
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